

Eggs of *Stylogaster* Macquart (Diptera: Conopidae) on Madagascan Muscids (Diptera: Muscidae)

Marcia S. Couri¹ and Adrian C. Pont²

¹ Museu Nacional, Universidade Federal do Rio de Janeiro, Quinta da Boa Vista, 20940-040, Rio de Janeiro, Brazil; Email: mcouri@atglobal.net; ² Oxford University Museum of Natural History Parks Road, Oxford OX1 3PW, U.K.; Email: pont.muscidae@btinternet.com.

The genus *Stylogaster* Macquart (Diptera, Conopidae) is represented by five species in Madagascar. All of the species are known to oviposit their dart-like eggs on cockroaches and calyprate Diptera. Seven genera of Muscidae have previously been recorded as hosts, including two unnamed species of *Dichaetomyia* from Madagascar. The present paper records seven additional Madagascan muscid hosts: *Deltotus factus* Seguy, *Deltotus viola* Zielke, *Dichaetomyia apicalis* (Zielke), *Dichaetomyia basialaris* (Zielke), *Dichaetomyia tristis* (Zielke), *Neomyia setulosa* (Zielke), and *Phaonia*, sp. nov. The records for *Deltotus* and *Neomyia* are the first for these genera. A brief discussion of their associations is given.

During a study of the muscid flies from Madagascar collected by the “Madagascar Arthropod Biodiversity Project,” a program developed by the California Academy of Sciences (Couri et al., in prep.), eggs of *Stylogaster* Macquart (Diptera, Conopidae) were observed on some specimens.

The genus *Stylogaster* occurs in North and South America, Africa south of the Sahara, Madagascar, parts of Asia, the Philippines, and New Guinea (Smith 1967). Fourteen species are known from the Afrotropical region, five of them occurring in Madagascar — *S. camrasi* Stuckenberg, 1963; *S. malgachensis* Camras, 1962; *S. pauliani* Camras, 1962; *S. seguyi* Camras, 1962 and *S. seyrigi* Séguy, 1932 (Smith 1980).

The larvae of *Stylogaster* species are parasites on cockroaches and calyprate Diptera, and the females are often seen hovering over the heads of marching columns of army ants (Hymenoptera: Dorylinae) and darting after their hosts, which are fleeing from the ant columns (Smith and Peterson 1987). Because of its remarkable biology and morphology, the genus is placed in its own subfamily, the Stylogastrinae.

Stuckenberg (1963) recorded *Stylogaster* eggs on some Muscidae species in southern Africa: *Dichaetomyia serena* (Stein), *Dichaetomyia* sp. nov., *Dichaetomyia quadrata* (Wiedemann), *Dimorphia setulosa* (Stein), *Dimorphia tristis* (Wiedemann) and *Pyrellina marsya* (Walker) (as *P. chrysolotus* [Walker]). In that publication, he pointed out that these species were all similar in appearance (*Dichaetomyia*-shape) and all were pale brownish or yellowish-brown in colour, except *P. marsya*, which is a dark-blue species with tergite V yellow.

Smith (1967) mentioned two unnamed species of *Dichaetomyia* from Madagascar impaled with *Stylogaster* eggs. In 1969, Smith added new records of adult muscids with *Stylogaster* eggs belonging to the genera *Helina* Robineau-Desvoidy, *Haematobosca* Bezzi (as *Bdellia* Enderlein), *Phaonia* Robineau-Desvoidy, and *Stomoxys* Geoffroy, and he also discussed their association with ants or mammalian dung (Smith 1969).

Lopes (1937) first noted the distinctive species-level characters of some of the *Stylogaster* dart-like eggs, and Smith (1967) gave a key for the identification of the Afrotropical (and Malagasy) species of *Stylogaster*, based on the morphology of the egg.

Except for the egg, the life-histories of species in this genus are little known. The morphology of the larvae is restricted to a first instar larva extracted from an egg found in *Calodexia* (Diptera, Tachinidae), and what may have been a second instar larva in a cockroach, both described by Rettenmeyer (1961).

What little else is known of the biology of *Stylogaster* was also reviewed by Rettenmeyer (1961), the early literature by Smith (1966), and more recent knowledge of the biology and taxonomy by Smith (1967).

The aim of this paper is to record the new data obtained on the Madagascan muscid hosts of *Stylogaster* and to present a brief discussion on this association.

MATERIALS AND METHODS

The materials studied are in the entomological collections of the California Academy of Sciences (CAS, San Francisco, California, USA).

The colour photos were made using Syncroscopy/JVC Auto-Montage with a Leica M 420 optical microscope.

RESULTS AND DISCUSSION

About 1800 muscid specimens from Madagascar were examined and eleven of them (approximately 0.7%), belonging to seven species, were found to be impaled with *Stylogaster* eggs:

Deltotus faciens Seguy, 1935: **MADAGASCAR: Fianarantsoa Province:** Ranomafana National Park, Vohiparara, at broken bridge, elev. 1100 m; 21°13.57'S 47°22.19'E, malaise trap, in high altitude rainforest; 31 March–8 April 2002, collection code MA-02-09A-23, 1 male, CASENT 3010583; 26–31 March 2002, R. Harin'Hala, collection code MA-02-09A-22, 1 male, CASENT 3009402; Belle Vue at Talatakely, elev. 1020 m, 21°15.99'S 47°25.21'E, malaise trap, secondary tropical forest. 12–19 February 2002, R. Harin'Hala, collection code MA-02-09C-16, 1 female, CASENT 3009764.

Deltotus viola Zielke, 1972: **MADAGASCAR: Fianarantsoa Province:** Ranomafana National Park, Vohiparara, at broken bridge, elev. 1110 m; 21°13'57"S 47°22'19"E, malaise trap, in high altitude rainforest, 31 March–8 April 2002, R. Harin'Hala, collection code MA-02-09A-23, 1 female, CASENT 3010581; 1 female, CASENT 3010584.

Dichaetomyia apicalis (Zielke, 1972): **MADAGASCAR: Fianarantsoa Province:** Ranomafana National Park, Vohiparara, at broken bridge, elev. 1100 m; 21°13'57"S 47°22'19"E, malaise trap, in high altitude rainforest, 14–26 June 2002, collection code MA-02-09A-32, 1 female, CASENT 3010318.

Dichaetomyia basialaris (Zielke, 1972): **MADAGASCAR: Fianarantsoa Province:** Ranomafana National Park, Belle Vue at Talatakely, elev. 1020 m; 21°15.99'S 47°25.21'E, malaise trap, secondary tropical forest, 14–21 January 2002, R. Harin'Hala, collection code: MA-02-09C-12, 1 male, CASENT 3009843.

Dichaetomyia tristis (Zielke, 1972): **MADAGASCAR: Toliara Province:** Andohahela National Park, Col du Sedro, 3.8 km 113° ESE Mahamavo, 37.6 km 341° NNW Tolagnaro; 24°45'50"S 46°45'6"E, pitfall trap – montane rainforest, elev. 900 m, 21–25 January 2002, Fisher, Griswold et al., collection code: BLF5013, 1 female, CASENT 3009365. **Fianarantsoa Province:** Ranomafana National Park, Radio tower at forest edge, elev. 1130 m; 21°15'05"S 47°24'43"E, malaise trap, mixed tropical forest. 15–21 December 2001, R. Harin'Hala, collection code: MA-02-09B-07, 1 male, CASENT 3010857.

Neomyia senulosa (Zielke, 1972): **MADAGASCAR: Antsiranana Province:** Marojejy National Park, Manantenina River, 28.0 km 38° NE Andapa, 8.2 km 333° NNW Manantenina, elev. 450 m; 14°26'12"S 49°46'30"E, malaise trap — rain forest, 12–15 November 2003, B.L. Fisher et al., collection code BLF8723, 1 female, CASENT 3009084.

Phaonia sp. nov. **MADAGASCAR: Fianarantsoa Province:** Ranomafana National Park, Belle Vue at Talatakely, elev. 1020 m; 21°15'99"S 47°25'21"E, malaise trap, secondary tropical forest, 12–19 February 2002. R. Harin'Hala, collection code: MA-02-09C-16, 1 male, CASENT 3009762.

Table 1 summarizes the host, sex, site and number of eggs.

All these species are new muscid host records for *Stylogaster*. *Deltotus* Séguy, which is endemic to Madagascar, and *Neomyia* Walker are new genus records.

Speculation on the association between the muscid flies, *Stylogaster*, and army ants has been made in the literature, but as the ant subfamily Dorylinae is entirely absent from some parts of Africa and from Madagascar, it is clear that at least some species of *Stylogaster* have no obligatory association with these ants (Stuckenberg 1963).

TABLE 1: Madagascan muscid flies with eggs of *Stylogaster*

<i>Host species</i>	<i>Sex</i>	<i>Site of egg</i>	<i>Number of eggs</i>
<i>Deltotus facetus</i> Séguy	male	scutellum	1
	female	mesonotum (presuturally)	1
		tergite 5	1
<i>Deltotus viola</i> Zielke	female	mesonotum (postsuturally)	1
		eye	1
	female	postpronotum	1
<i>Dichaetomyia apicalis</i> (Zielke)	female	eye	1
		tergite 3	1
	male	mesonotum (postsuturally)	1
<i>Dichaetomyia basialaris</i> (Zielke)	female	mesonotum (presuturally)	1
		mesonotum (postsuturally)	1
<i>Neomyia setulosa</i> (Zielke)	female	mesonotum (presuturally)	1
		notopleuron	1
<i>Phaonia</i> sp. nov.	male	eye	1

Stuckenberg (*ibid.*) pointed out that most of his records of muscids impaled with eggs were of species that are attracted to faeces, such as *Dimorphia* Malloch, and that all his recorded specimens were females. Thus, he suggested that *Stylogaster* species might search for their hosts in the vicinity of dung, where female muscids, less active at oviposition sites, would be easier prey. Stuckenberg recorded 19 specimens, all females and all from Southern Africa, impaled with *Stylogaster* eggs. Smith (1967) called attention to the fact that not all *Dichaetomyia* larvae are coprophagous, and in his study both sexes were about equally attacked. In a subsequent paper, Smith (1969) listed 23 specimens impaled with eggs, 20 females and 3 males. The sex ratio in the present study was 50:50.

Of the genera recorded here, Skidmore (1985) stated that *Dichaetomyia* species are strongly attracted to dung, and there are many records in the literature of these flies visiting excrement (human faeces, bovine, horse or goat dung). For instance, *Neomyia* breed mainly or exclusively in bovine dung, whereas *Phaonia* develops mainly in mosses and humus soil, rarely utilizing dung as a larval pabulum. Nothing is known about the life-history of *Deltotus*, but its systematic position among the metallic green/blue Muscini suggests that it, too, has coprophagous larvae.

In analyzing what attracts Malagasy *Stylogaster* to deposit eggs on host muscids, we examined large series of *Dichaetomyia* spp., *Helina lucida* (Stein), and *Stomoxys*. None were found to have



FIGURES A–D (left). (A) *Phaonia* sp. n., male, head, $\frac{3}{4}$ view. (B) *Deltotus facetus* Séguy, female, head and part of mesonotum, lateral view. (C) *Deltotus viola* Zielke, female, abdomen, lateral view. (D) *Deltotus facetus* Séguy, female, abdomen, lateral view

Stylogaster eggs. *Helina lucida* have coprophagous larvae whereas *Dichaetomyia* ssp. and *Stomoxys* do not. Although Stuckenberg (1963) suggested that the pale coloration of South African *Dichaetomyia* might be attracting *Stylogaster* for oviposition, the pale coloration of Malagasy *Dichaetomyia* ssp. and dark coloration of *Helina lucida* and *Stomoxys* appeared to have no effect on oviposition rates.

The maximum number of eggs per specimen recorded here was three. However, Stuckenberg (1963) recorded a maximum of four and Smith (1967) five.

In his discussion of the presence of the eggs on muscids, Stuckenberg (1963) wondered whether the muscids are the hosts themselves or whether they are carriers of the eggs to their true hosts.

Rettenmeyer (1961) suggested that the abundant muscid flies found over ant swarms in Panamá could be attracted to the noise, odour, or appearance of other flies flying over the ant swarms, rather than to the ants themselves. He also mentioned that other muscid species, which are attracted to the swarms, breed in the remains of booty deposited by the ants outside their nests.

Much more field study and collecting should be done to elucidate the associations among *Stylogaster*, muscids, and ants, and to discover the life-history of *Stylogaster* itself. Eggs of *Stylogaster* have been also recorded from other calyptrate Diptera found over raiding columns of army ants, such as *Calodexia* and *Androeuropyos* (Tachinidae) in Panamá (Rettenmeyer 1961).

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